Behavioral Responses of Odontocetes to Playback of Anthropogenic and Natural Sounds

Peter L. Tyack
Woods Hole Oceanographic Institution
266 Woods Hole Road, MS #50
Woods Hole, MA 02543
Phone: (508) 289-2818 Fax: (508) 457-2041 Email: ptyack@whoi.edu

Award Number: N00014-07-10988

LONG-TERM GOALS

The long-term goal of this research project is to safely study responses of beaked whales to naval sounds in order to understand the causal chain of events leading from sound exposure to risks of stranding and to measure the exposure required to elicit responses that are safe but that indicate potential for risk. The project is designed to provide critical information required to develop measures to protect beaked and other whales from risk of exposure to sonar and other sounds.

OBJECTIVES

A critical objective for understanding possible links between sonar exposure and injury or stranding involves developing techniques to safely study how beaked whales respond to sound. This project has objectives to adapt, test and refine protocols for studying beaked whales using established sound playback experiment methods; to define responses of beaked whales and other species of odontocete whales to mid-frequency active (MFA) sonar and natural sounds such as those from killer whales; and to measure exposure parameters for sounds that evoke a behavioral response.

APPROACH

The approach for this study involves controlled exposures of sound stimuli to tagged and non-tagged whales where the scientific team controls the sound source. This ONR project is part of a larger BRS research program involving several other PIs and institutions. The team funded under this grant helped design and plan the study, built, tested and calibrated sound and orientation recording tags (Digital Archival Tag – DTAG), tagged beaked and pilot whales, and analyze the results. Field efforts were conducted at the Atlantic Undersea Test and Evaluation Center (AUTEC) on Andros Island, Bahamas, adjacent to the deep canyon of the Tongue of the Ocean (TOTO). AUTEC has a 600 square mile, 82 hydrophone, permanent range of bottom mounted hydrophones which can be used for detecting and locating cetaceans on the range using the NUWC marine mammal monitoring on navy ranges (M3R) equipment. This capability of locating whales requires close collaboration with NUWC and the marine mammal monitoring team. Tagging research has been conducted on this site with support from SERDP to establish baseline data and work under this grant involves continued collaboration with the Bahamas Marine Mammal Research Organization (BMMRO) for vessels and staff. Other collaborators include the Sea Mammal Research Unit (SMRU) at the University of St. Andrews, NUWC, BMMRO, Marine Acoustics Incorporated, NATO Undersea Research Centre, the

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
2007		**00-00-2007 to 00-00-2007**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Behavioral Responses of Odontocetes to Playback of Anthropogenic and Natural Sounds	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Woods Hole Oceanographic Institution,266 Woods Hole Road, MS #50,Woods Hole,MA,02543**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

Bioacoustics Research Program at Cornell University, NOAA Acoustics Program, and personnel at the AUTEC range, all of which are covered under separate funding.

WORK COMPLETED

The first field effort was held 11 August – 31 September 2007 at AUTEC on Andros Island, Bahamas. Data were collected from 10 tag deployments, 6 on Blainville's beaked whales and 4 on pilot whales. A total of 109 hours of data were collected from tags, 74 hours from beaked whales and 34 hours from pilot whales. The data collected by the tag included sounds produced by the tagged animal, environmental and anthropogenic sounds received by the animal, details of the animal's movements in terms of its diving, swimming speeds, changes in orientation and swimming actions. Playbacks were performed on 3 of the tagged whales, 1 beaked whale and 2 pilot whales. This is a lower total than was anticipated. Long stretches of poor weather incompatible with tagging, especially toward the end of the field effort, meant that effective tagging opportunities were greatly reduced from expectations based upon historical weather records. At this stage, only the results from the playback to the beaked whale have been subjected to preliminary analysis.

RESULTS

- After a pre-exposure dive, a MFA sonar playback was conducted on a tagged, female adult *Mesoplodon densirostris*.
- The MFA playback started at a source level (SL) of 152 dB re 1 µPa, a few minutes after the whale began producing ultrasonic clicks. The SL was then increased by 3 dB every 25 s in a ramp-up procedure, reaching a maximum SL of 212 dB after 9 minutes. The MFA signal was then played back at maximum SL every 25 sec for 6 minutes.
- The first ping detected on the tag and for which received level (RL) could be estimated, had an RL of ~95 dB (Figure 1) Figure 2 illustrates the sounds of whale clicks and the MFA sonar signal as recorded on the whale with the DTAG.
- After 10 min into the playback, the whale appeared to stop clicking earlier than usual, when the RL at the whale was ~145 dB. The playback continued for several minutes once cessation of clicking was confirmed. The maximum RL recorded at the whale was ~152 dB. Because this dive was so short, she had an unusually low number of whale buzzes (very rapid series of clicks) which are indicative of foraging events.
- The whale then ascended more slowly than usual and, as a result, had a longer than normal ascent.
- The whale surfaced, where her behavior appeared normal. After about 2 hours she started another deep foraging dive (Figure 1). Once she started clicking at depth, a playback of killer whale sounds was started.
- The killer whale playback started at an initial SL of 130-140 dB, a few minutes after the whale began producing ultrasonic clicks. The SL was then increased by about 5 dB about every 30 sec in a ramp-up procedure, reaching a maximum SL of 190-203 dB after 10 minutes. The killer whale playback was stopped several minutes after the whale stopped clicking, before the ramp up process had reached maximum SL.

- The first killer whale sounds detected on the tag for which RL could be estimated had a RL of ~96 dB (Figure 1).
- The whale stopped clicking about 5 minutes into the killer whale playback, a shorter clicking period than usual. The received level of the killer whale sounds recorded on the tagged whale just before she ceased vocalizing was ~117 dB. The sound exposure at the whale continued for several minutes once the cessation of clicking was confirmed. The maximum RL recorded at the whale was ~134 dB.
- This exposure dive had the shortest overall clicking period, the lowest number of buzzes, the slowest ascent rate, and the longest ascent among the beaked whale deep foraging dives recorded at TOTO in BRS-07 from 5 individual whales (Figure 3).
- As soon as the killer whale playback stopped, the beaked whale started swimming away from the location of the sound source and she continued swimming on a much straighter course than usual, although she made two additional deep foraging dives during this movement, the first of which was 4.8 hours after the killer whale exposure dive. This inter-dive interval is longer than any of the other times between deep foraging dives of *Mesoplodon* recorded during the BRS at AUTEC.
- By the time the tag was released from the whale, 10 hours after the end of the dive that contained the last playback, the whale had traveled approximately 20 km (10.8 nm) from the playback location at an average horizontal speed of about 0.5 m/s (1 kt). Details of this movement pattern are preliminary and will be improved after the tag data are geo-referenced at several points throughout the record.

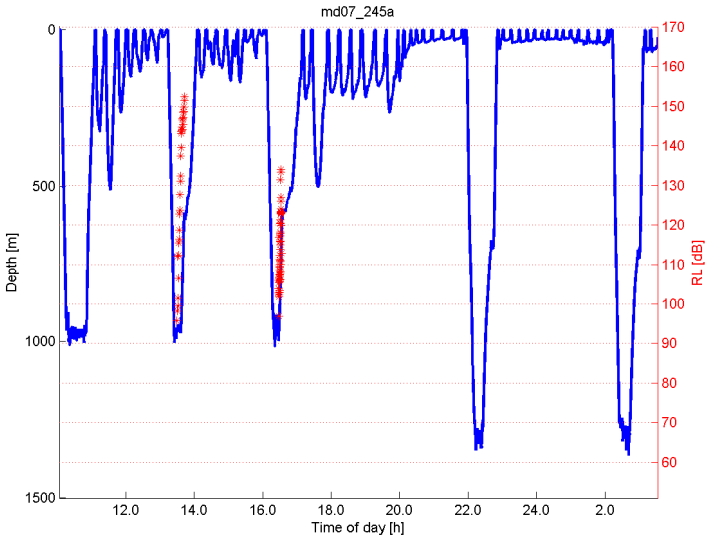

Figure 1: The dive profiles of the female beaked whale involved in the playback. This shows the depth of the whale (blue) during the time that the tag was attached. It shows that the whale made 5 deep (>500m) foraging dives. During two of these dives (numbers 2 and 3) she was exposed to a playback of MFA sonar (dive 2) and killer whale (dive 3) sounds. Each of the red stars shows when the tag on the whale received playback sound and the received sound level (dB re 1 µPa) as indicated on the right hand axis. It can be seen that the playback sound was ramped up through the deep dive which corresponds to the time when the whales was clicking. The playback was ended in both cases within several minutes of cessation of vocalization.

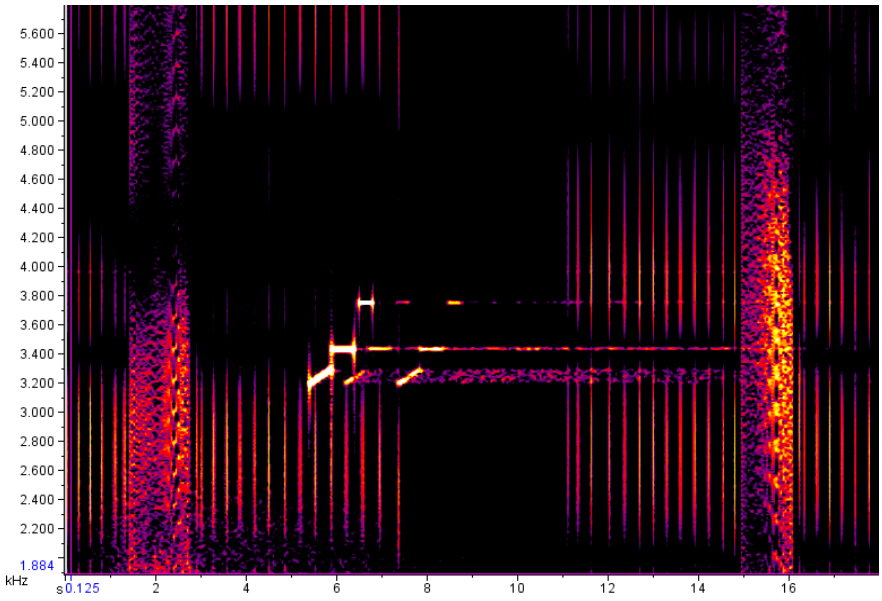

Fig 2 – Audio spectrogram of click series and two buzzes produced by Blainville's beaked whale and MFA sonar sound as recorded from DTAG on whale during playback of MFA sonar sound. The whale clicks appear as vertical lines, the whale buzzes as the more complex patterns from 1-3sec and from 15-16 sec and the MFA sonar signal runs from 5-7 sec. with echoes and reverberation continuing for about 10 sec.

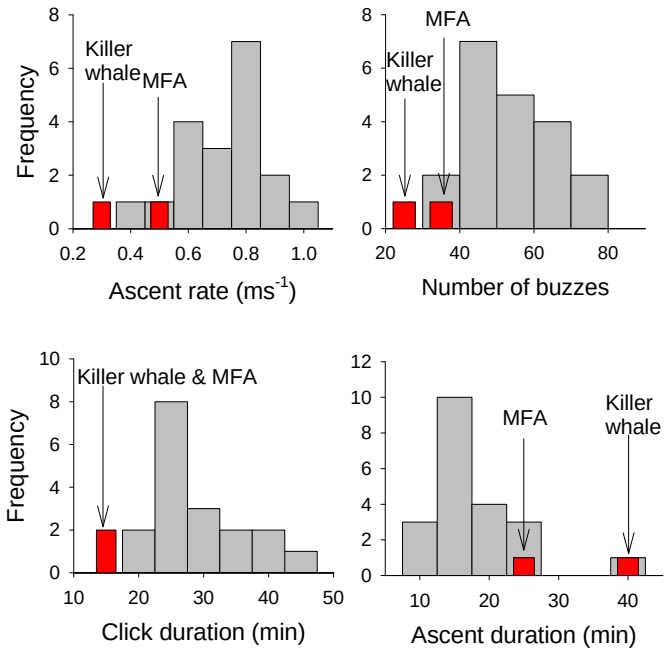

Figure 3: Histograms showing the frequency distributions of four variables measured across all the deep foraging dives for Blainville's beaked whales within the TOTO. The grey bars show those dives made without playbacks whereas the red bars represent the measurements made for the dives when playback occurred.

The field effort has seen a successful progression toward our main objective which is to characterize behavioral responses that could be used to measure the effects of MFA sonars on beaked whales and other species. While further analyses of the data are required, we believe that we have obtained a relatively clear set of behavioral responses by an adult female beaked whale to the controlled playback of MFA sonar and killer whale sounds. The tags were able to quantify the acoustic exposure associated with the onset of the responses. However, it must be noted that this experiment involved two exposures to a single individual with limited baseline information. Now that we have demonstrated that this experimental paradigm can provide useful information, without harm or undue risk to the animals, additional results using a similar paradigm are needed. Additionally, the absence of negative control stimuli means that this test must be repeated with other stimuli that do not elicit such a response. Such tests would allow us to better understand the sound features that elicit responses.

IMPACT/APPLICATIONS

These early results have to be interpreted with care because the analyses are preliminary and stem from a single experiment involving the response of one individual. There is also a limited set of baseline data to characterize normal behavior. A greater sample size is required before robust conclusions can be drawn. However, this result helps to narrow the high level of uncertainty about the possible responses of Blainville's beaked whales to sonar and predator calls, and it provides a basis for further experiments to better understand the nature of the response. Nothing in the responses observed to date suggests that the playback experiment presented any risk to the whale. Additional questions that need to be addressed include, but are not limited to:

- Was the prolonged movement away from the sound source after playback of killer whale calls the result of the killer whale stimulus alone or was it influenced by the MFA playback, and the order in which the sounds were presented?
- Do these animals respond in this way to other novel sounds irrespective of whether they simulate MFA sonar or a predator?
- What is the range of acoustic parameters associated with these responses.

Once these questions are answered, this project will offer potential for several methods to mitigate adverse effects of sonar on beaked and other whales. Measurement of the acoustic exposure that elicits a response associated with potential for risk will provide critical data allowing prediction of effects of sonar operations. Definition of the acoustic parameters associated with the responses may suggest ways to reduce the probability of a response. And measurement of responses of different species to different signals will help to define the extent of the risk.

The post-playback mitigation and monitoring observations, both vessel-based and aerial, were conducted at the start and end of the field effort and after both playbacks to ensure that there were no injured or stranded marine mammals in and around a large area surrounding the location of each playback. In some cases, weather and practical considerations extended the periods of time over which this monitoring was conducted, but for all playbacks there was extensive monitoring of both the waters and surrounding shorelines. No distressed, injured, or stranded animals were detected at any time.

TRANSITIONS

Not applicable

RELATED PROJECTS

SERDP: Acoustic Response and Detection of Marine Mammals on Navy Ranges Using a Digital Acoustic Recording Tag

REFERENCES

Not applicable

PUBLICATIONS

Not applicable

PATENTS

Not applicable

HONORS/AWARDS/PRIZES

Not applicable